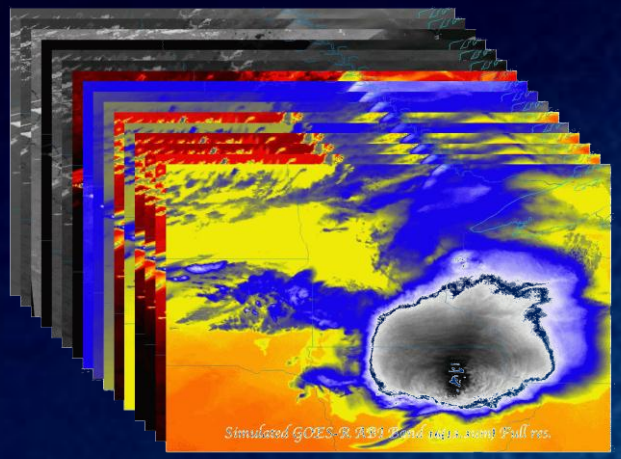
# Cloud and Moisture Imagery

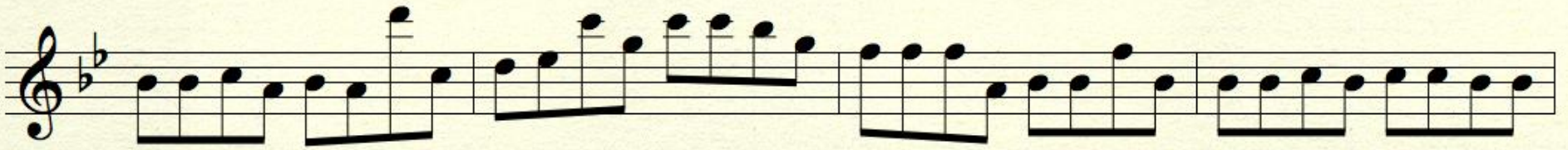


## May 1, 2012


*Presented By:* Tim Schmit
NOAA/NESDIS/STAR


Thanks to the whole imagery team!

*Tom Rink, CIMSS*
*Mat Gunshor, CIMSS*
*Kaba Bah, etc., CIMSS*
*AIT:*
*Walter Wolf, NOAA/NESDIS/STAR*
*William Straka, CIMSS*
*Wendy Zhang, Riverside Technology, Inc.*
*Etc.*
Liaisons
Don Hillger, *NOAA/NESDIS/STAR*
Steve Miller, CIRA, Etc.

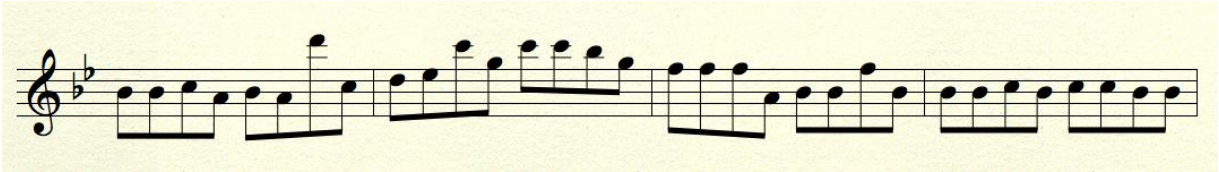


# Outline

- **Synopsis of GOES-R Product Algorithm**
  - Algorithm description
  - Product example(s)

- **Continuing AWG Validation Activities**
  - Latest algorithm performance statistics obtained
  - Examples (routine and deep-dive)
  - Showcasing of any validation tools developed

- **Thoughts, Plans, and Opportunities for:**
  - Real-time simulated ABI



# Products

- The purpose of the imagery team is two-fold:
  - Demonstrate how to convert from GRB scaled radiances (eg, GRB integers) to other physical units, such as radiance, brightness temperatures and brightness values.
  - Build files that can be used for processing most all of the ABI products, such as clouds, soundings, etc.

- Imagery is the key product for GOES-R.

- There are 54 KPP Cloud and Moisture Imagery End-Products (CMIP) (48 single band End-Products in netCDF format at the resolution native to each band and one multiband product at 2 km resolution in both netCDF & McIDAS Area file formats).
  - 16 products * 1 format (netCDF) * 3 coverage areas (Full Disk, CONUS, Mesoscale) Multiband products: 1 product * 2 formats (netCDF and McIDAS Area)* 3 coverage areas (Full Disk, CONUS, Mesoscale)

# Requirements – Cloud and Moisture Imagery

| Name | User & Priority (G, H, C, M) | Geographic Coverage | Vertical Resolution | Horizontal Resolution | Mapping Accuracy | Measurement Range | Measurement Accuracy | Refresh Rate/Coverage Time Option (Mode 3) | Refresh Rate Option (Mode 4) | Data Latency | Product Measurement Precision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cloud and Moisture Imagery | GOES-R | C | N/A | 2 km, with finer daytime observations | 1 km | N/A | N/A | 5 min | 5 min | 50 sec | N/A |
| Cloud and Moisture Imagery | GOES-R | FD | N/A | 2 km, with finer daytime observations | 1 km | N/A | N/A | 15 min | 5 min | 50 sec | N/A |
| Cloud and Moisture Imagery | GOES-R | M | N/A | 2 km, with finer daytime observations | 1 km | N/A | N/A | 30 sec | | 23 sec | N/A |

**C –** CONUS **FD –** Full Disk M - Mesoscale

# ABI Visible/Near-IR Bands

| Future GOES imager (ABI) band | Wavelength range (μm) | Central wavelength (μm) | Nominal subsatellite IGFOV (km) | Sample use |
|---|---|---|---|---|
| 1 | 0.45–0.49 | 0.47 | 1 | Daytime aerosol over land, coastal water mapping |
| 2 | 0.59–0.69 | 0.64 | 0.5 | Daytime clouds fog, inso-lation, winds |
| 3 | 0.846–0.885 | 0.865 | 1 | Daytime vegetation/burn scar and aerosol over water, winds |
| 4 | 1.371–1.386 | 1.378 | 2 | Daytime cirrus cloud |
| 5 | 1.58–1.64 | 1.61 | 1 | Daytime cloud-top phase and particle size, snow |
| 6 | 2.225–2.275 | 2.25 | 2 | Daytime land/cloud properties, particle size, vegetation, snow |



Schmit et al, 2005

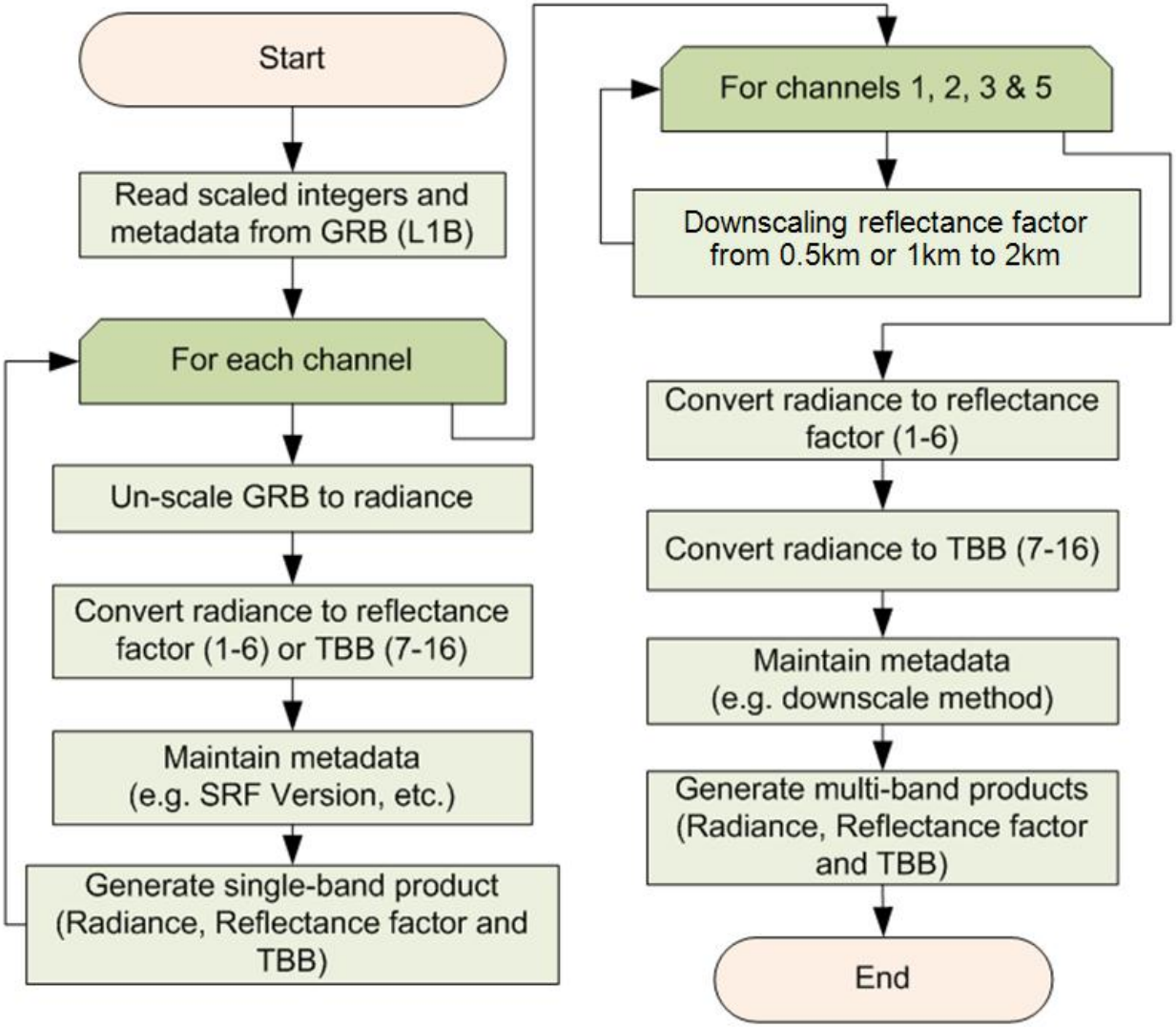
# ABI IR Bands

| | | | | |
|---|---|---|---|---|
| 7 | 3.80–4.00 | 3.90 | 2 | Surface and cloud, fog at night, fire, winds |
| 8 | 5.77–6.6 | 6.19 | 2 | High-level atmospheric water vapor, winds, rainfall |
| 9 | 6.75–7.15 | 6.95 | 2 | Midlevel atmospheric water vapor, winds, rainfall |
| 10 | 7.24–7.44 | 7.34 | 2 | Lower-level water vapor, winds, and $SO_2$ |
| 11 | 8.3–8.7 | 8.5 | 2 | Total water for stability, cloud phase, dust, $SO_2$ rainfall |
| 12 | 9.42–9.8 | 9.61 | 2 | Total ozone, turbulence, and winds |
| 13 | 10.1–10.6 | 10.35 | 2 | Surface and cloud |
| 14 | 10.8–11.6 | 11.2 | 2 | Imagery, SST, clouds, rainfall |
| 15 | 11.8–12.8 | 12.3 | 2 | Total water, ash, and SST |
| 16 | 13.0–13.6 | 13.3 | 2 | Air temperature, cloud heights and amounts |

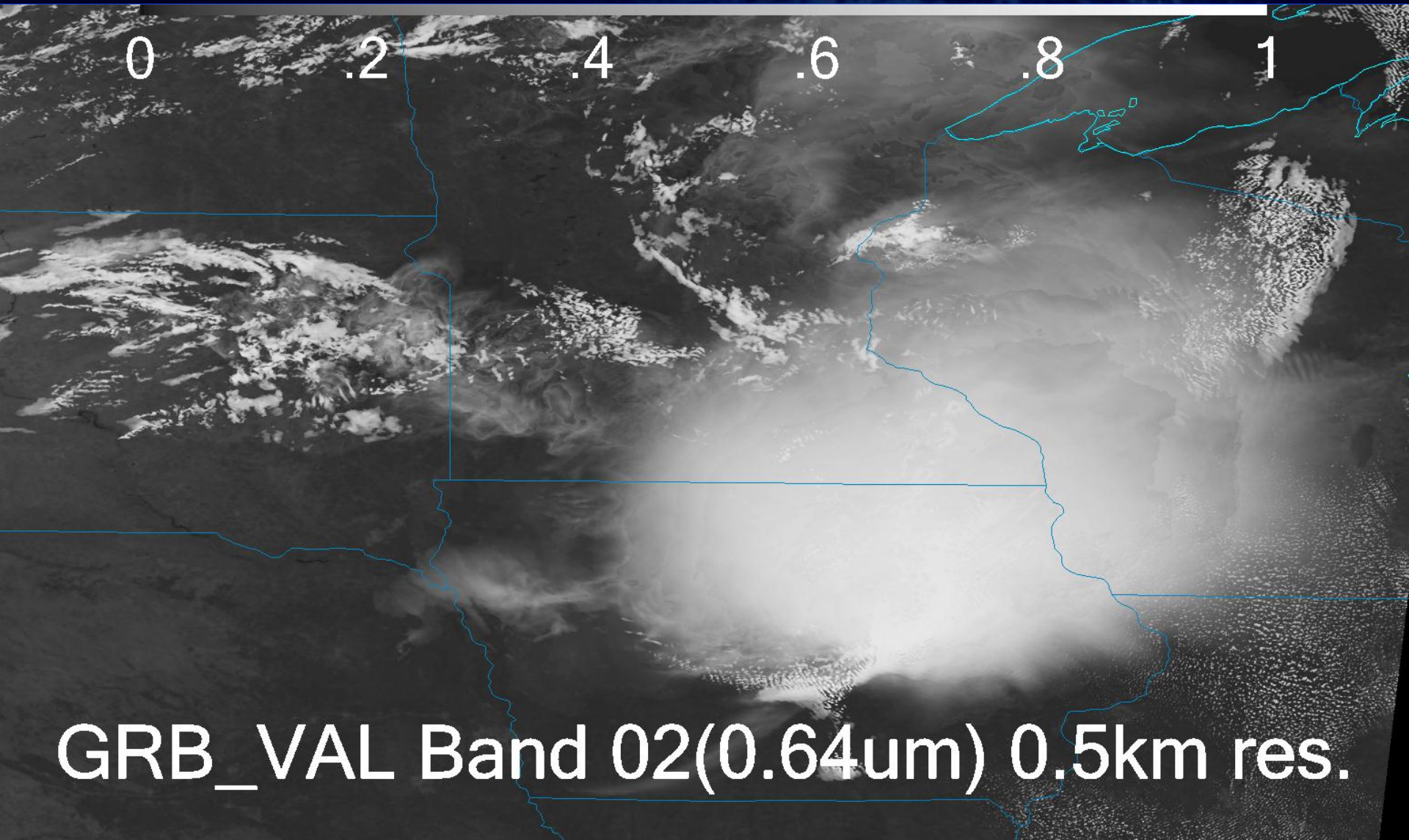


Schmit et al, 2005

# High level flowchart for generating CMIP



# Down-scaling



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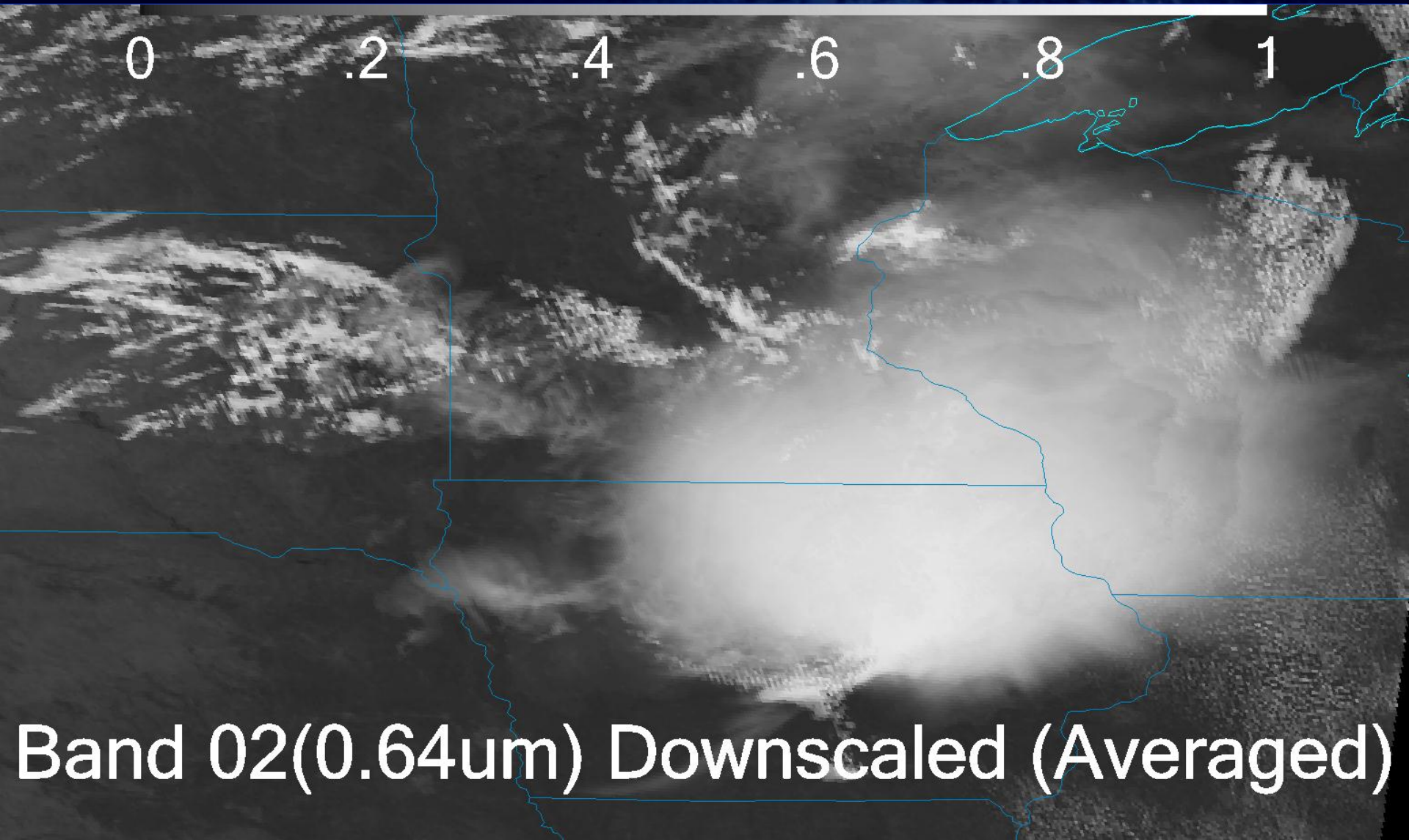

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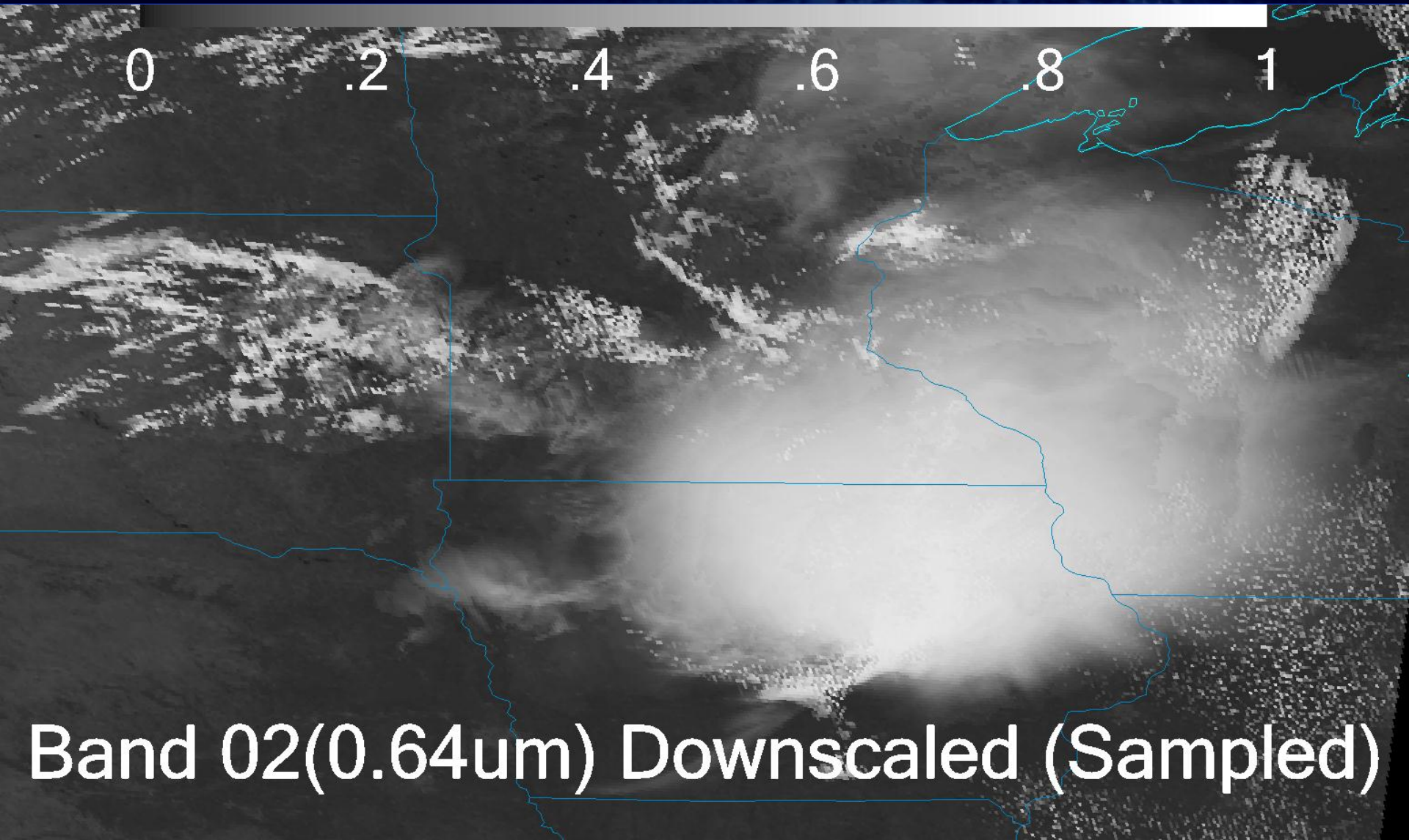
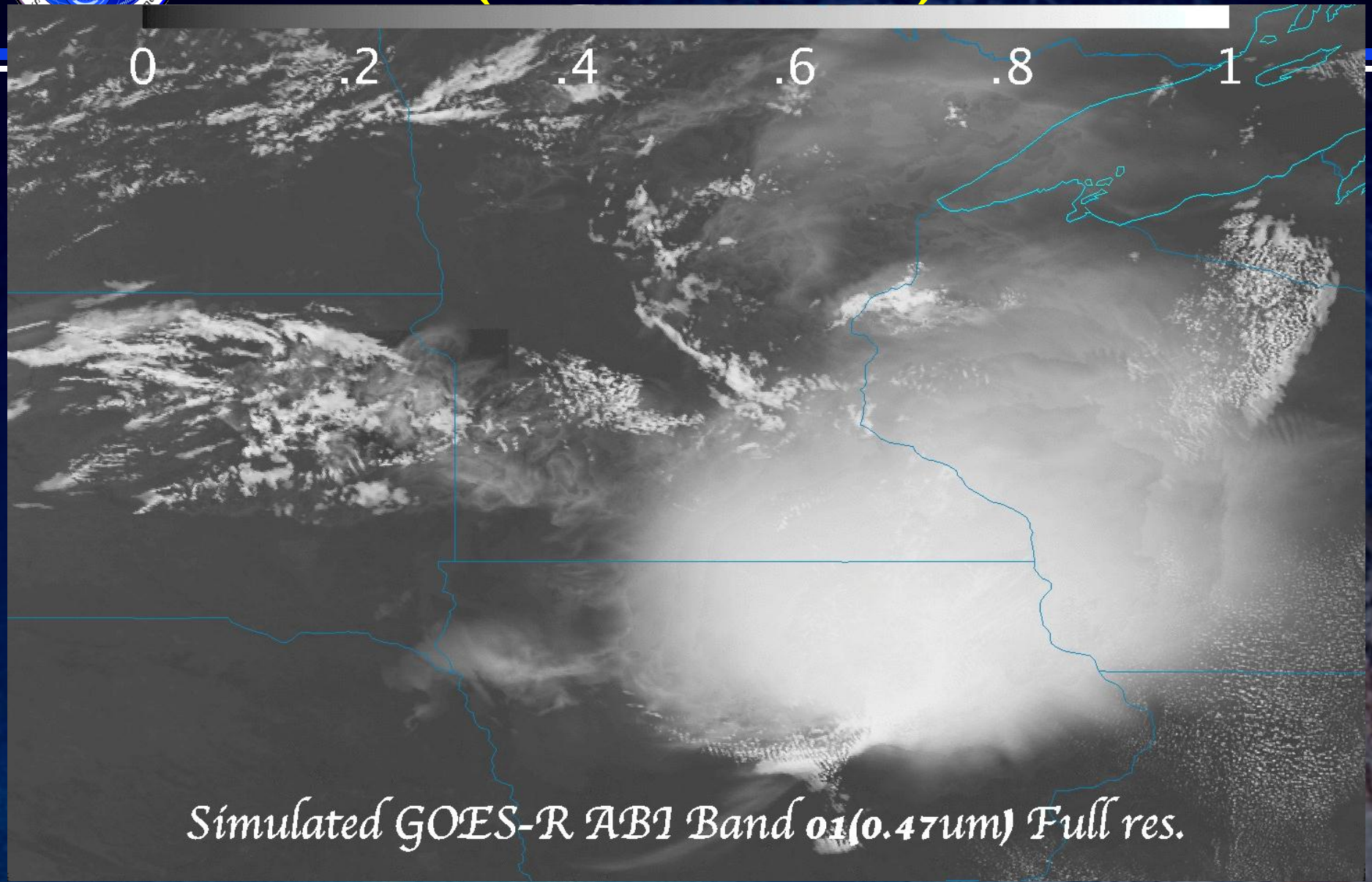


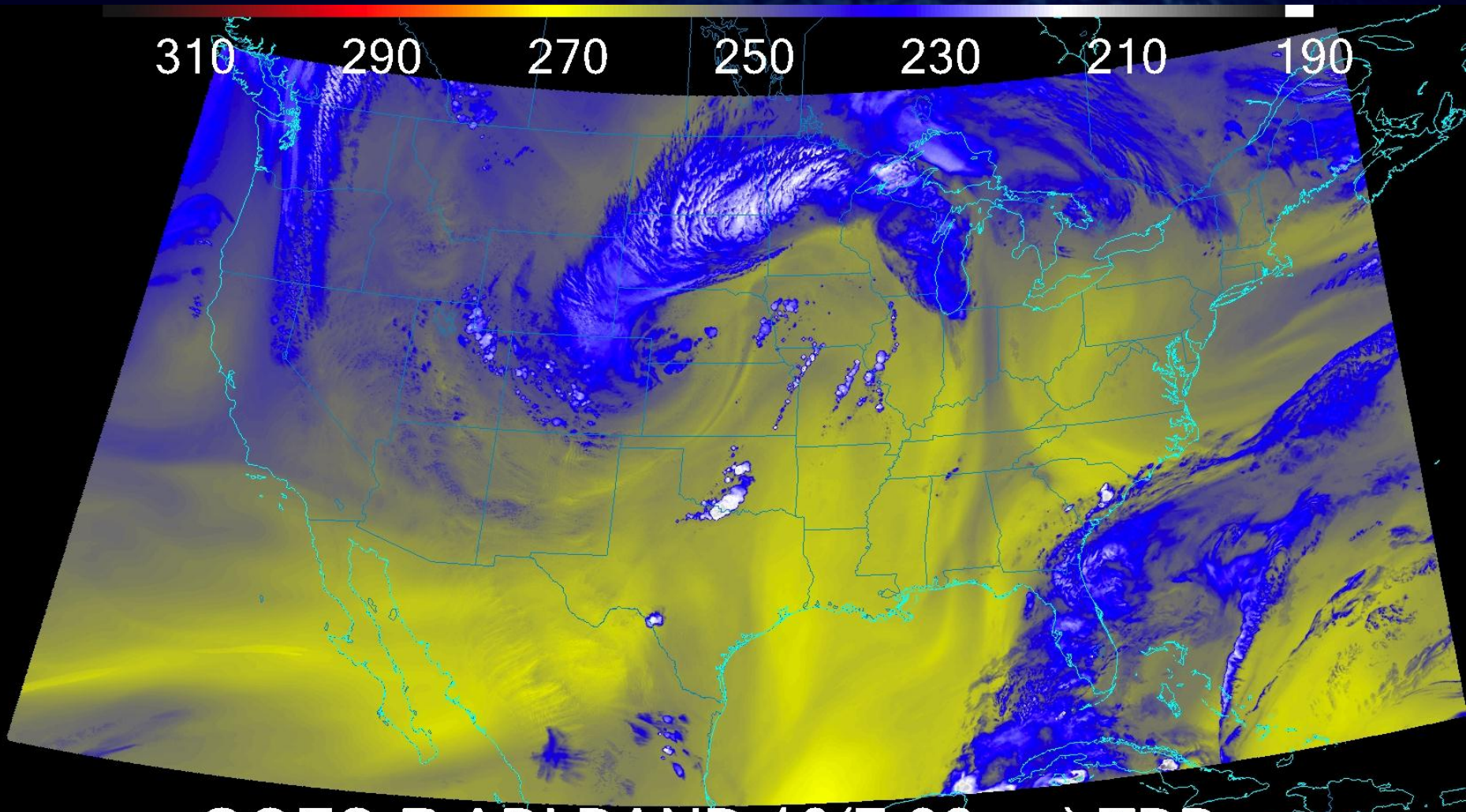
# Dataset Re-delivery

- Meso-scale (75W)
- CONUS (75W)
- Full Disk (137W)
- New units for the 6 visible/nearIR bands, FGF, etc.
- Single time only

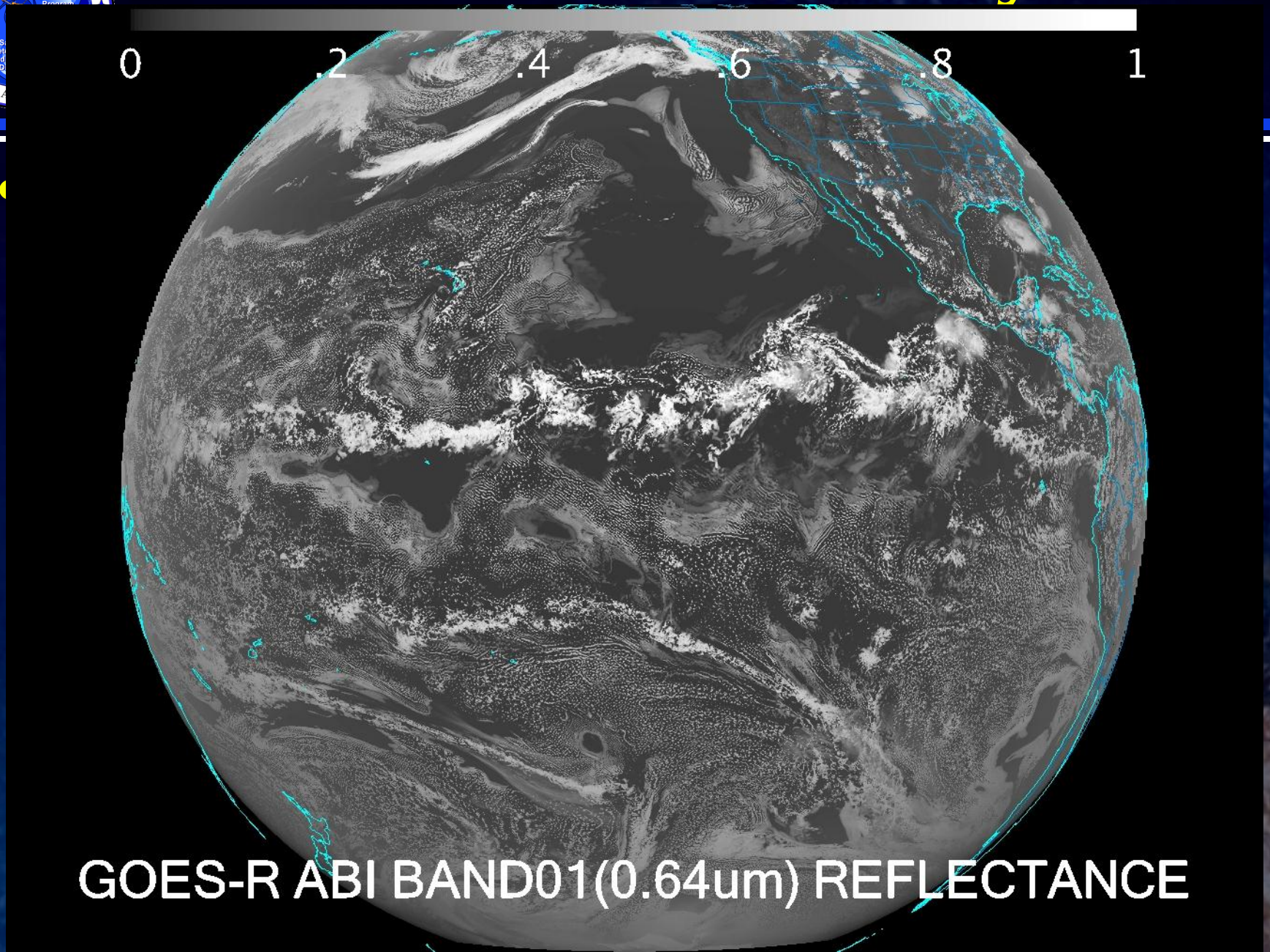
# Dataset Re-delivery (meso-scale)



# Dataset Re-delivery

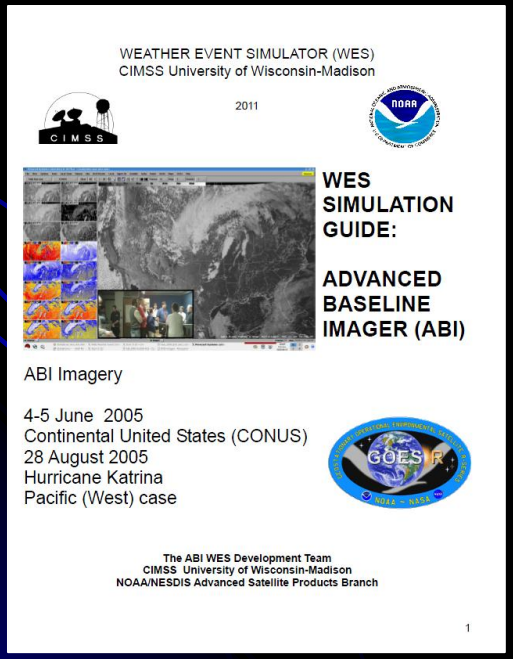


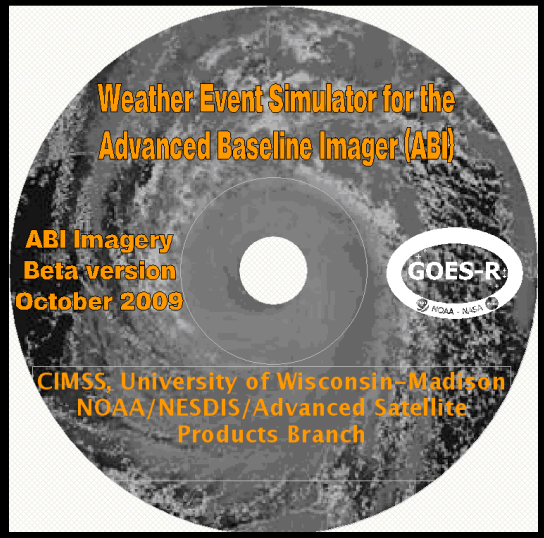
# Dataset Re-delivery



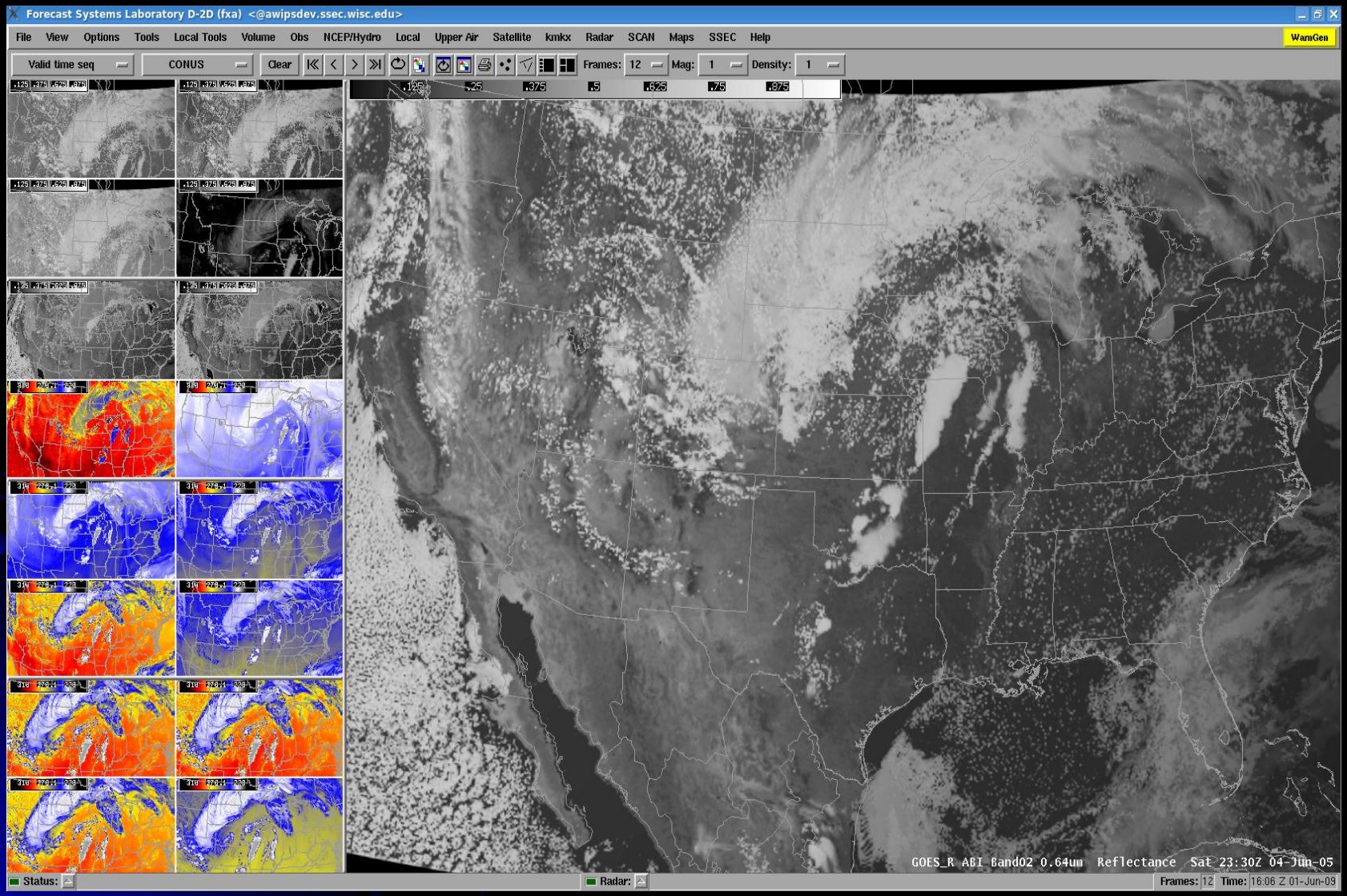
# ABI WES

- Contains simulated ABI for all bands for a June-2006 convective storm (CONUS and mesoscale), Hurricane Katrina, band differences, a WES guide, and images over the Pacific Ocean



# ABI in AWIPS


Forecast Systems Laboratory D-2D (fxa) <@awipsdev.ssec.wisc.edu>
File View Options Tools Local Tools Volume Obs NCEP/Hydro Local Upper Air Satellite kmkx Radar SCAN Maps SSEC Help
WarnGen
Valid time seq
CONUS
Clear
Frames: 12
Mag: 1
Density: 1
.125 .25 .375 .5 .625 .75 .875
GOES_R ABI Band02 0.64um Reflectance Sat 23:30Z 04-Jun-05
Status:
Radar:
Frames: 12
Time: 16:06 Z 01-Jun-09

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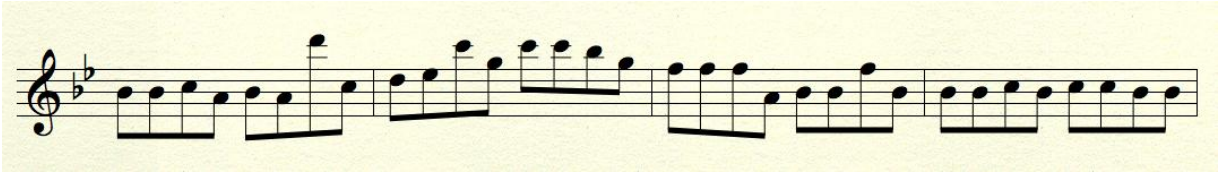
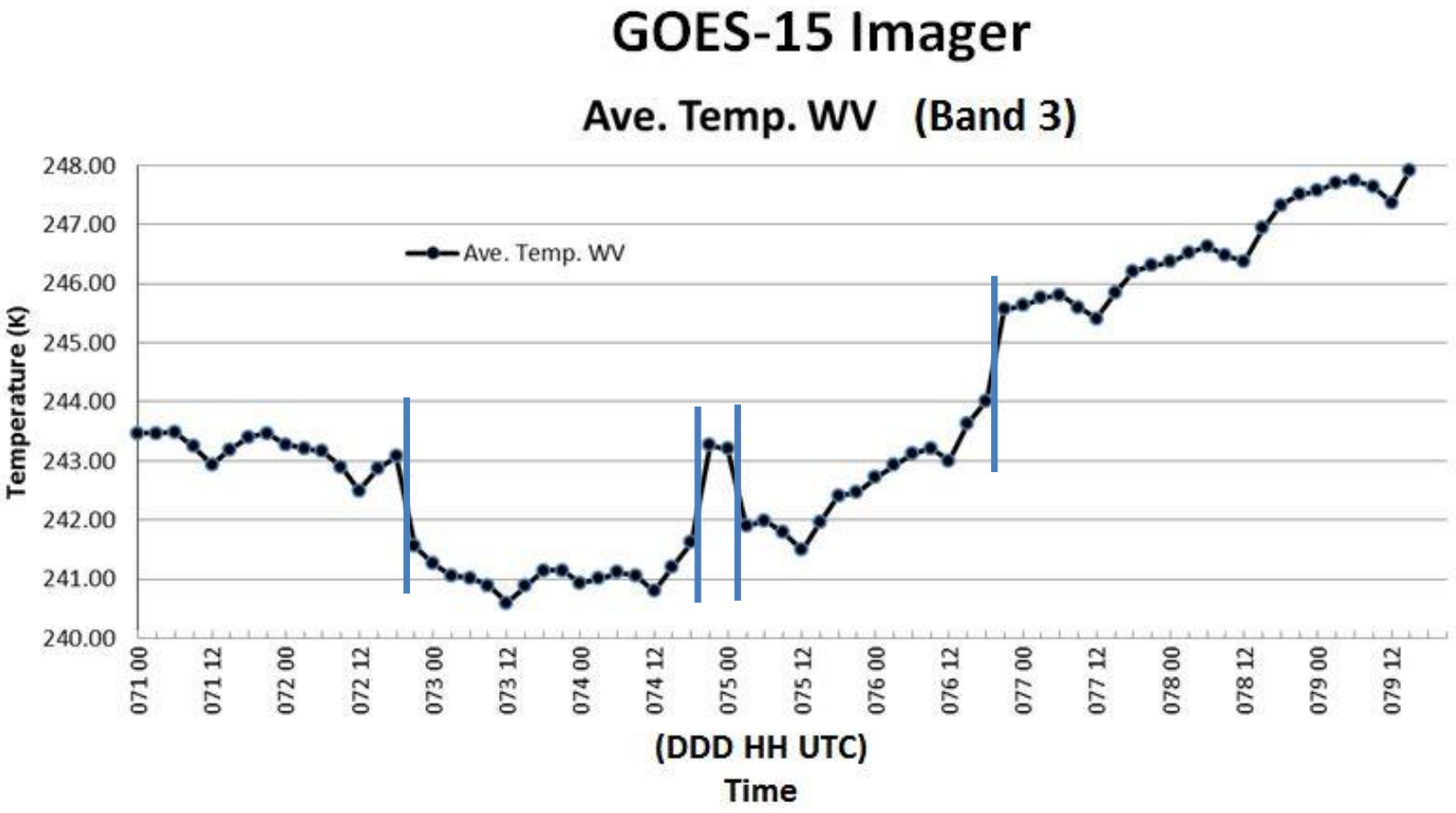
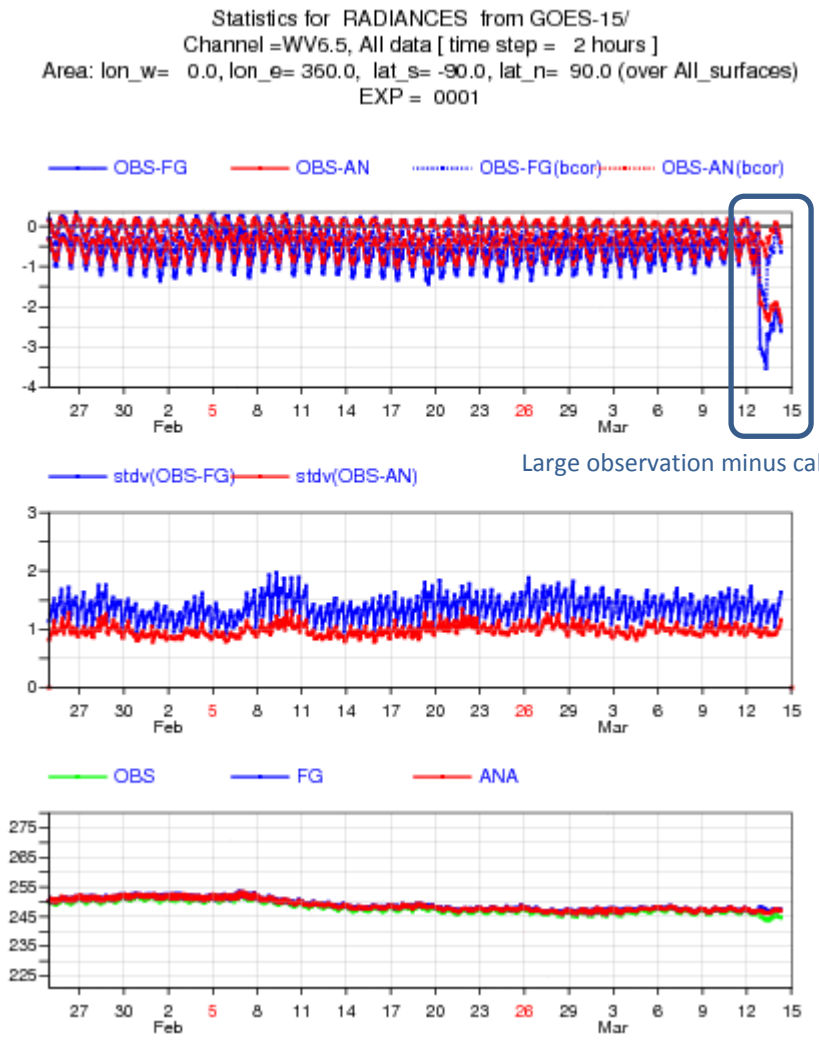


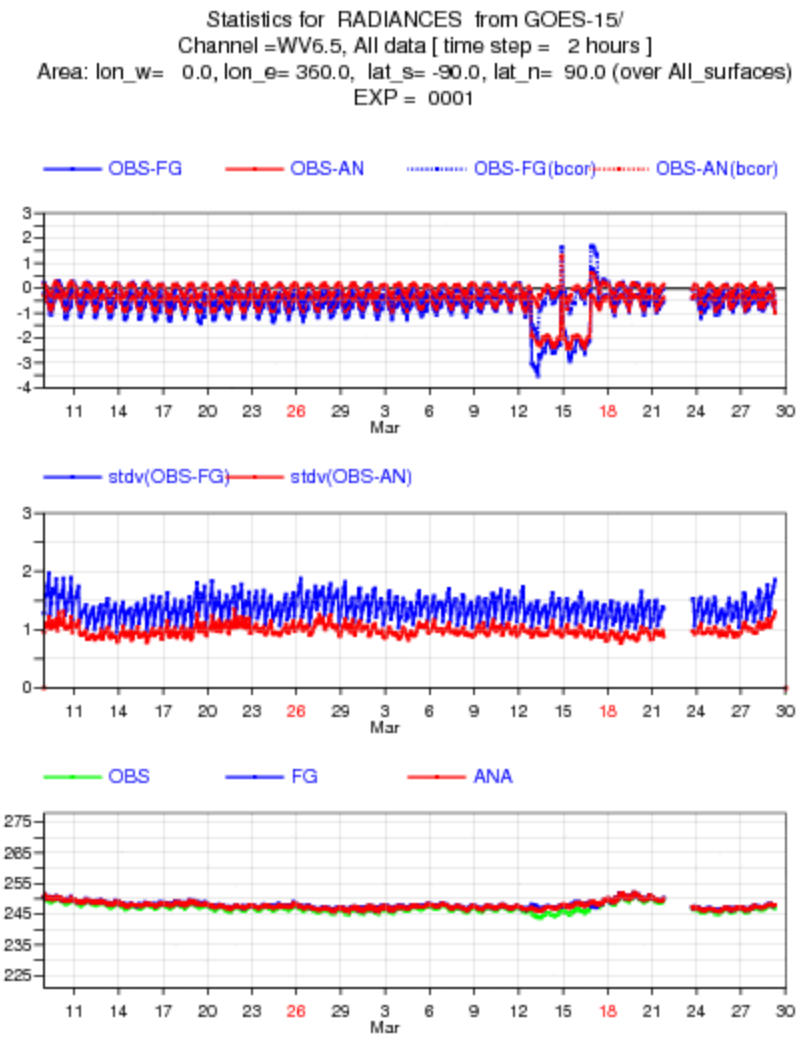



GOES Imager Water Vapor Mean brightness temperatures over water from 90 S to 90 N and 110 W to 170 W.

# GOES-15 Imager Calibration Anomaly (monitored by ECMWF)




Large observation minus calculation

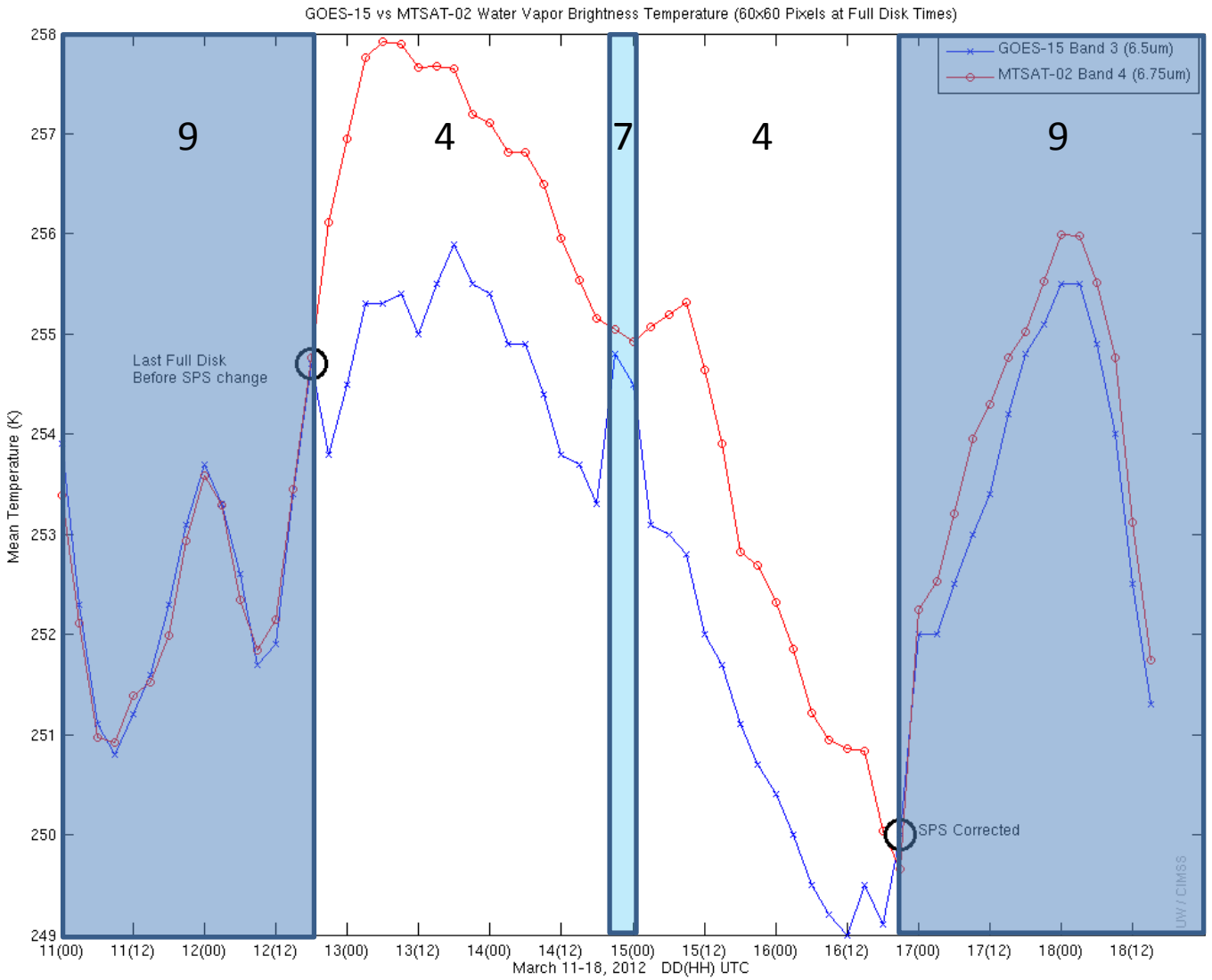



Beginning of the anomaly

Encompassing the anomaly

# GOES-15 Imager Calibration Anomaly (by SPS)

SPS:




*GOES-15 Imager water vapor band compared to co-located MTSAT values. Note large brightness temperature differences beginning near 21UTC on March 12, 2012. Plus, the SPS unit used for the generation of GVAR is noted (obtained from the GVAR signal). Image from: CIMSS and STAR.*

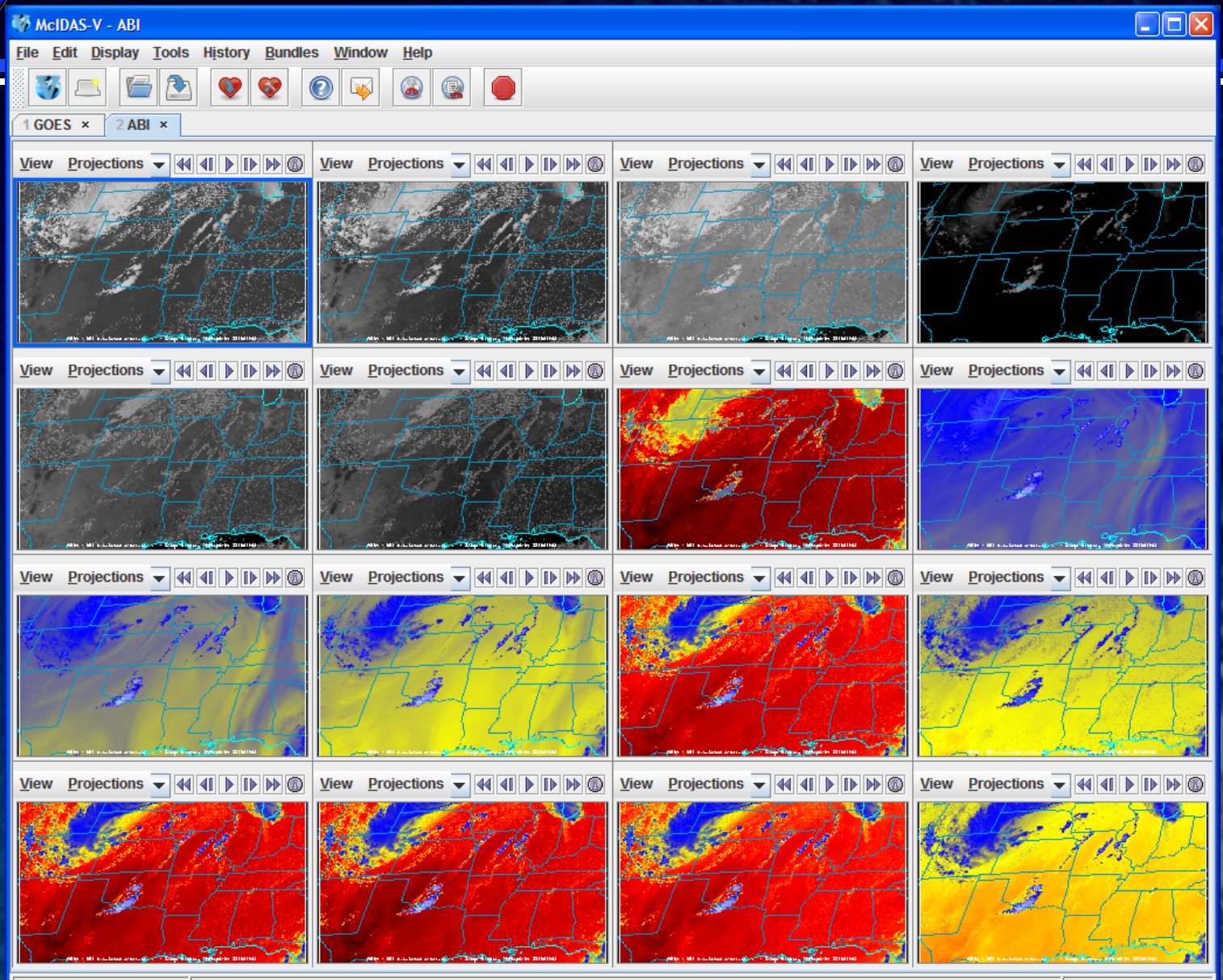
# Routine Validation Tools

This (automated) tool set includes, but is not limited to:

- Time series of reflectance factor (RF) and radiances/brightness temperatures
- Statistics of RF, radiances/brightness temperatures
- Generate a host of images, thumbnail images
- Animations
- Monitor “forward model calc” vs “satellite obs” (Calibration function?)
- Monitor image quality
- Etc.

| |
|---|
| **Average of valid data samples** |
| **Number of valid data samples** |
| **Minimum value of valid data samples** |
| **Maximum value of valid data samples** |
| **Sum of valid data samples** |
| **Sum-of-squares of valid data samples** |
| **Total number of data samples within the sample set** |

# Example CMIP Output ABI bands in McIDAS-V

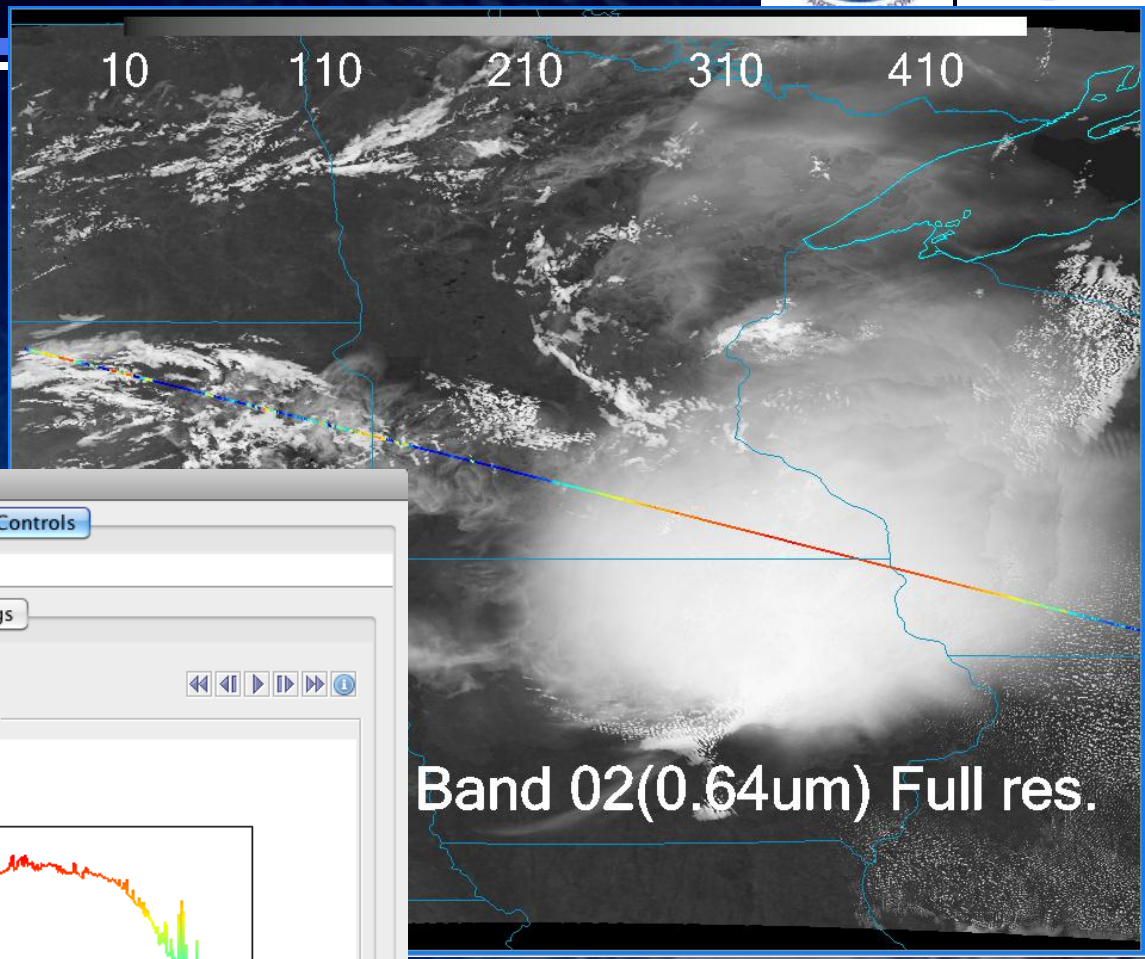


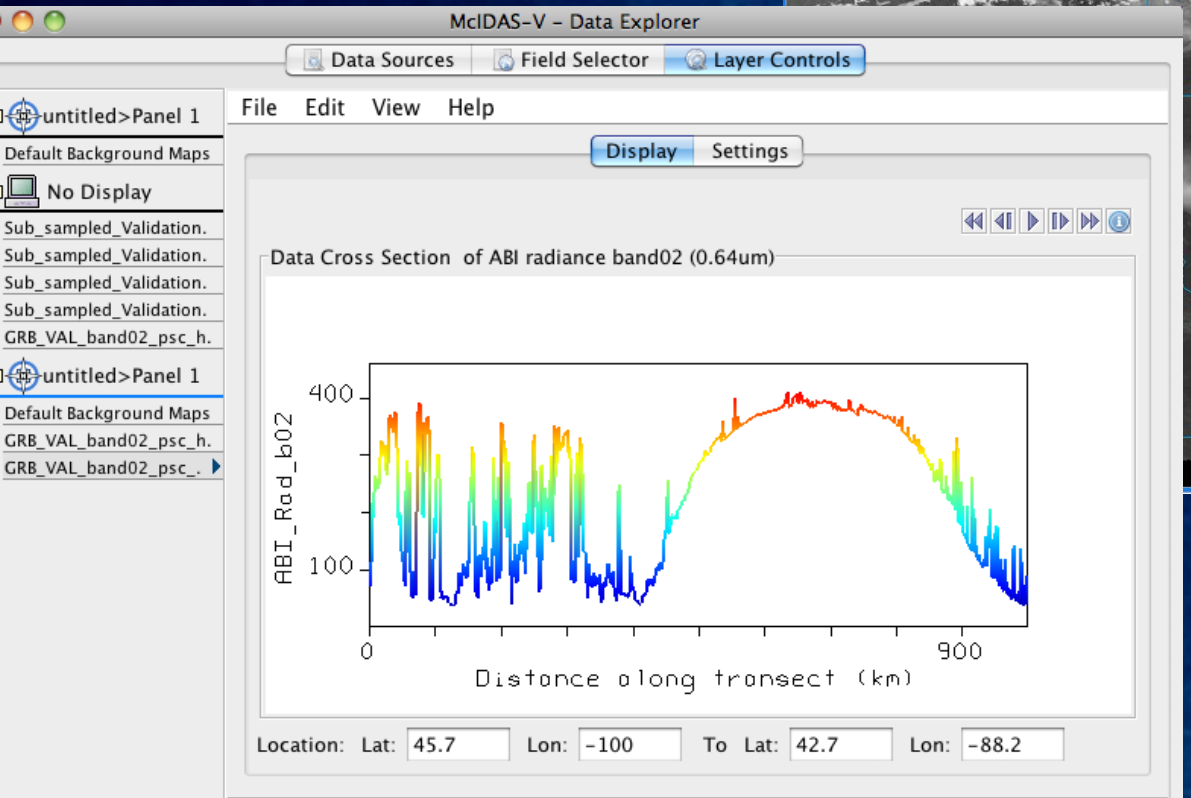
# ”Deep-Dive” Validation Tools

- This tool set includes, but is not limited to:
  - Additional Thumbnail images
  - Full size and/or zoomed images
  - Generate difference images
    - Temporal
    - Spectral
  - Times series of radiances/brightness temperatures
    - Longer time-series
  - Scatter plots, etc.
  - Statistics of radiances/brightness temperatures
    - Longer times series
  - “Forward Model Calc” vs “Satellite Obs” information
    - From raobs, NWP, etc.
  - Correlate image artifacts with calibration events
  - Compare to other imagery (e.g., VIIRS, etc.)
  - Etc.

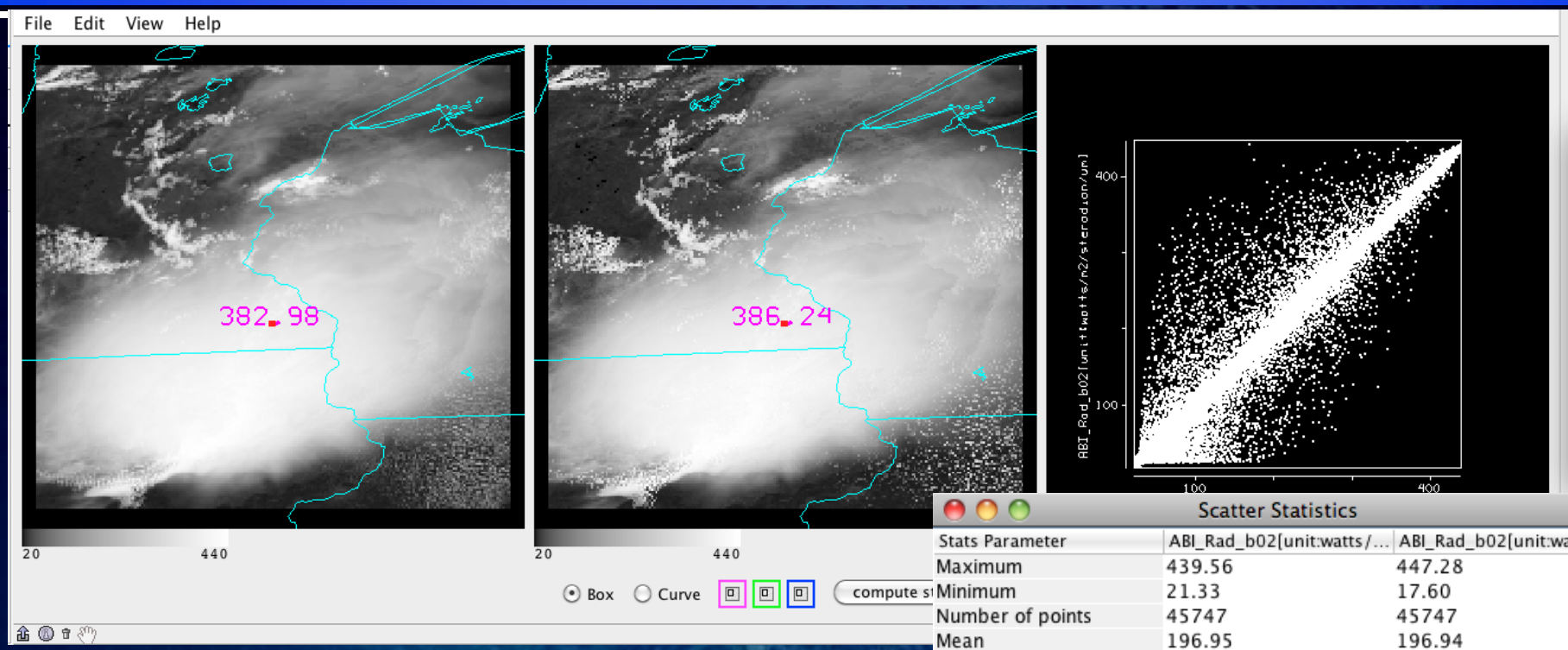
- McIDAS + scripts

# Transect (Mcidas-V)



# Interactive Scatter plot and Statistics




Scatter Statistics

| Stats Parameter | ABI_Rad_b02[unit:watts/... | ABI_Rad_b02[unit:watts/... |
|---|---|---|
| Maximum | 439.56 | 447.28 |
| Minimum | 21.33 | 17.60 |
| Number of points | 45747 | 45747 |
| Mean | 196.95 | 196.94 |
| Median | 188.78 | 191.22 |
| Variance | 1.669146e+04 | 1.723394e+04 |
| Kurtosis | -1.333 | -1.364 |
| Std Dev | | |
| Correlation | 0.98193 | |
| Difference Maximum | 210.69 | |
| Difference Minimum | -273.38 | |
| Difference Mean | 0.01082 | |
| Area [km^2] | | |

Save As CSV


CIMSS Realtime GOES Derived Product Imagery - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://cimss.ssec.wisc.edu/goes/rt/sounder-dpi.php
Google
Most Visited http://www.osdpd.noaa...
CIMSS Realtime GOES Derive...
CIMSS GOES Realtime Derived Products
Sounder DPI
CIMSS
GOES Home
Home
Sounder DPI
Precipitable Water
Full GOES-E/W
Cont. US (GW/GE)
Cont. US - Low Layer
Cont. US - Mid Layer
Cont. US - Upper Layer
GOES-15
Cont. US w/ RAOB
Severe wx comparison
Sounder data (text)
Lifted Index
Cont. US (GW/GE)
GOES-15
Cont. US w/ RAOB
Severe wx comparison
CAPE
Cont. US
Cloud Products
Full GOES-E/W CTP
Cont. US CTP (GW/GE)
GOES-15
Cont. US ECA
Cloud data (text)
Total Column Ozone
US
DPI GIF Archive
Archive directory
All band display
GOES East
GOES West
GOES-15
GOES E/W Single Band
Band 3 (14.1µm)
Band 5 (13.4µm)
Band 8 (11.0µm)
Band 8 (GOES-15)
Band 10 (7.5µm)
Band 11 (7.0µm)
Band 12 (6.5µm)
Sounder DPI
Precipitable Water
Compare
Click on links below to view a product
Full GOES-East/West Coverage
Conterminous US - Total (GOES-W/E)
Conterminous US - Low Layer (GOES-W/E)
Conterminous US - Mid Layer (GOES-W/E)
Conterminous US - Upper Layer (GOES-W/E)
Conterminous US (GOES-15)
Conterminous US with RAOB
Comparison with reported severe weather
Sounder PW listings in text format
Lifted Index
Conterminous US (GOES-W/E)
Conterminous US (GOES-15)
Conterminous US with RAOB
Comparison w/ reported severe weather
CAPE
Conterminous US
Cloud Products
Full GOES-East/West Coverage CTP
CTP Conterminous US (GOES-W/E)
CTP Conterminous US (GOES-15)
ECA Conterminous US (GOES-W/E)
GOES Sounder Cloud Properties (text)
Clear
Compare
Click on links below to view a product
GOES East
GOES West
GOES-15
GOES E/W Conterminous US Single Band Composite Images
Band 3 (14.1 µm)
Band 5 (13.4 µm)
Band 8 (11.0 µm)
Band 8 (GOES-15)
Band 10 (7.4 µm)
Band 11 (7.0 µm)
Band 12 (6.5 µm)
Band 15 (4.4 µm)
Band 15 (GOES-15)
Band 17 (4.0 µm)
Band 19 (0.70 µm)
Band 19 (GOES-15)
Wisconsin DPI
GOES PW DPI/guess/RAOB
GOES LI DPI/guess/RAOB
GOES PW/LI/CTP w/ Vis/IR
Ozone
Full GOES-East/West Coverage
DPI GIF Archive
Archive of GOES Sounder derived products
Clear
Find:
Next
Previous
Highlight all
Match case
http://cimss.ssec.wisc.edu/goes/rt/viewdata.php?product=lisr_us

CIMSS Realtime GOES Derived Product Imagery - Mozilla Firefox

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http://cimss.ssec.wisc.edu/goes/rt/viewdata.php?product=compare

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CIMSS Realtime GOES Derive...

# CIMSS GOES Realtime Derived Products

## Compare

Full screen

Home

**Sounder DPI**

Precipitable Water
- Full GOES-E/W
- Cont. US (GW/GE)
- Cont. US - Low Layer
- Cont. US - Mid Layer
- Cont. US - Upper Layer
- GOES-15
- Cont. US w/ RAOB
- Severe wx comparison
- Sounder data (text)

Lifted Index
- Cont. US (GW/GE)
- GOES-15
- Cont. US w/ RAOB
- Severe wx comparison

CAPE
- Cont. US

Cloud Products
- Full GOES-E/W CTP
- Cont. US CTP (GW/GE)
- GOES-15
- Cont. US ECA
- Cloud data (text)

Total Column Ozone
- US

DPI GIF Archive
- Archive directory

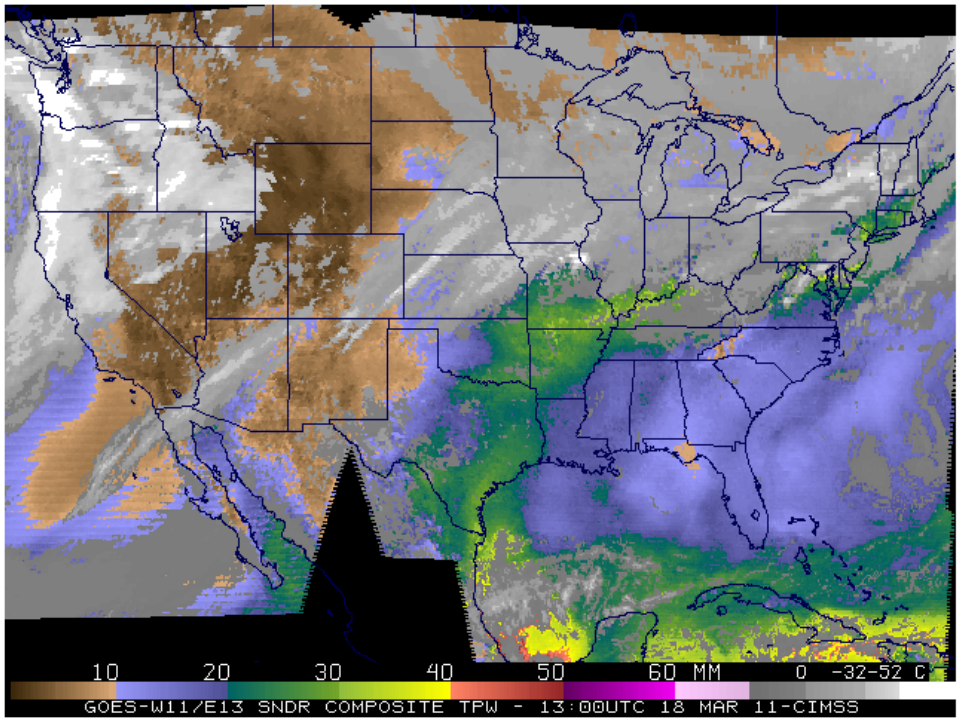
All band display
- GOES East
- GOES West
- GOES-15

GOES E/W Single Band
- Band 3 (14.1μm)
- Band 5 (13.4μm)
- Band 8 (11.0μm)
- Band 8 (GOES-15)
- Band 10 (7.5μm)
- Band 11 (7.0μm)

Latest | Toggle | Fader | Panel

Start | Show | Set Animation Speed | < | > | Zoom | Refresh

Left click - toggle on/off; Right click - show frame




× Find: Next Previous Highlight all Match case

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- Band 11 (7.0μm)

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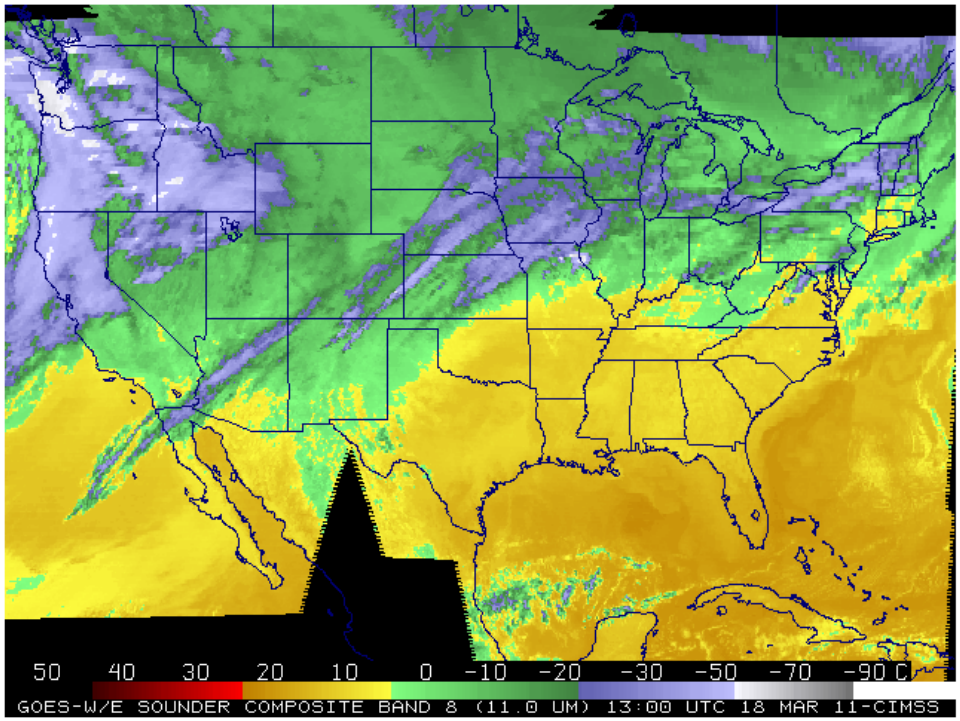
Left click - toggle on/off; Right click - show frame




× Find: Next Previous Highlight all Match case

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http://cimss.ssec.wisc.edu/goes/rt/viewdata.php?product=compare&

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CIMSS Realtime GOES Derive...

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CAPE
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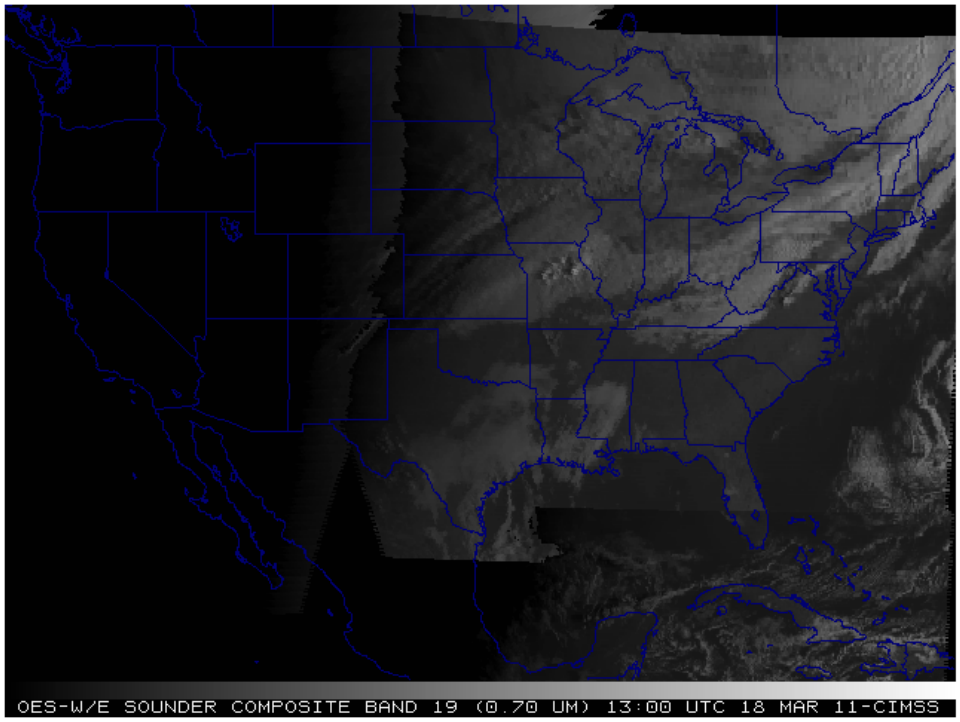
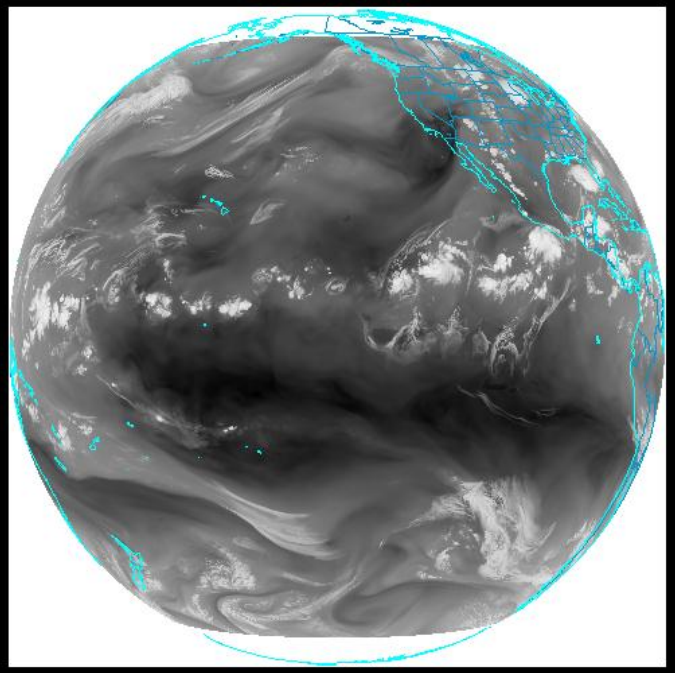
Left click - toggle on/off; Right click - show frame




× Find: Next Previous Highlight all Match case

Loaded 100%

# In ABI FGF (137W)



Working on the Fixed Grid Format (FGF) for ABI

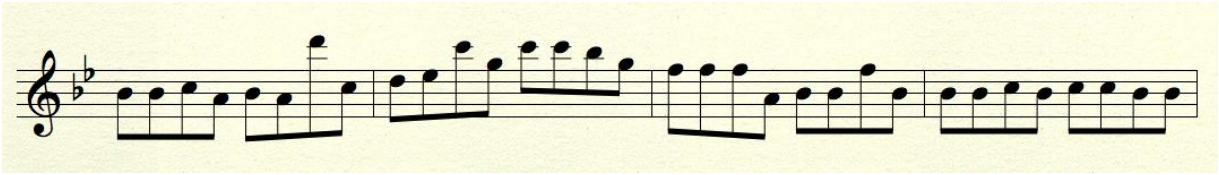
- Iterating with Harris personnel verifying ABI FGF vs CGMS defined “Normalized Geostationary Projection”
- Continued development of beta version of software to compute transforms to and from FGF to longitude and latitude.
- Comparison of earth locations for 2km fixed grid between Harris and SSEC code shows a very close match.
- Continuing effort to define critical metadata for geostationary projections in CF/CF-satellite.

# Outline

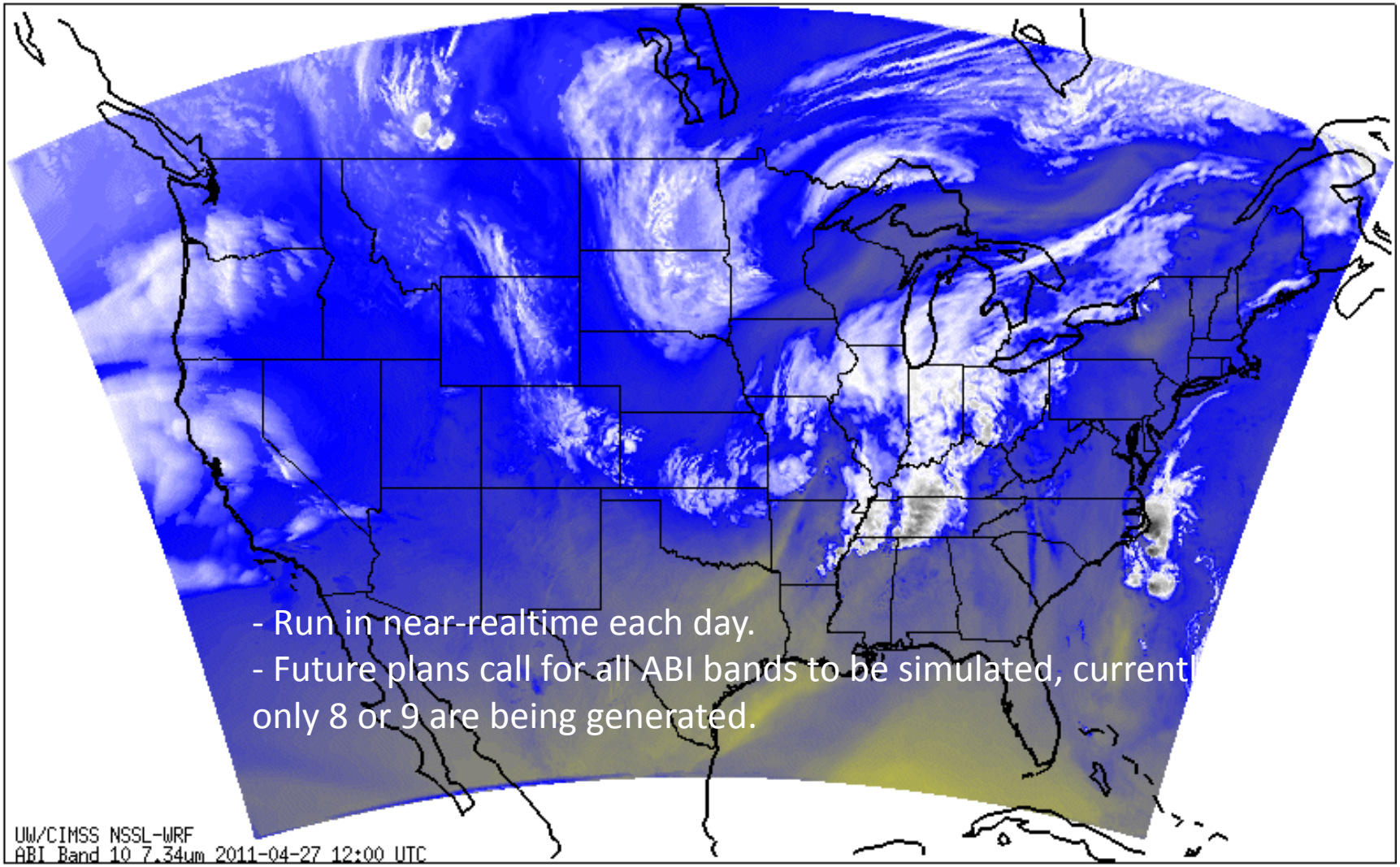
- **Synopsis of GOES-R Product Algorithm**
  - Algorithm description
  - Product example(s)

- **Continuing AWG Validation Activities**
  - Latest algorithm performance statistics obtained
  - Examples (routine and deep-dive)
  - Showcasing of any validation tools developed

- **Thoughts, Plans, and Opportunities for:**
  - Real-time simulated ABI

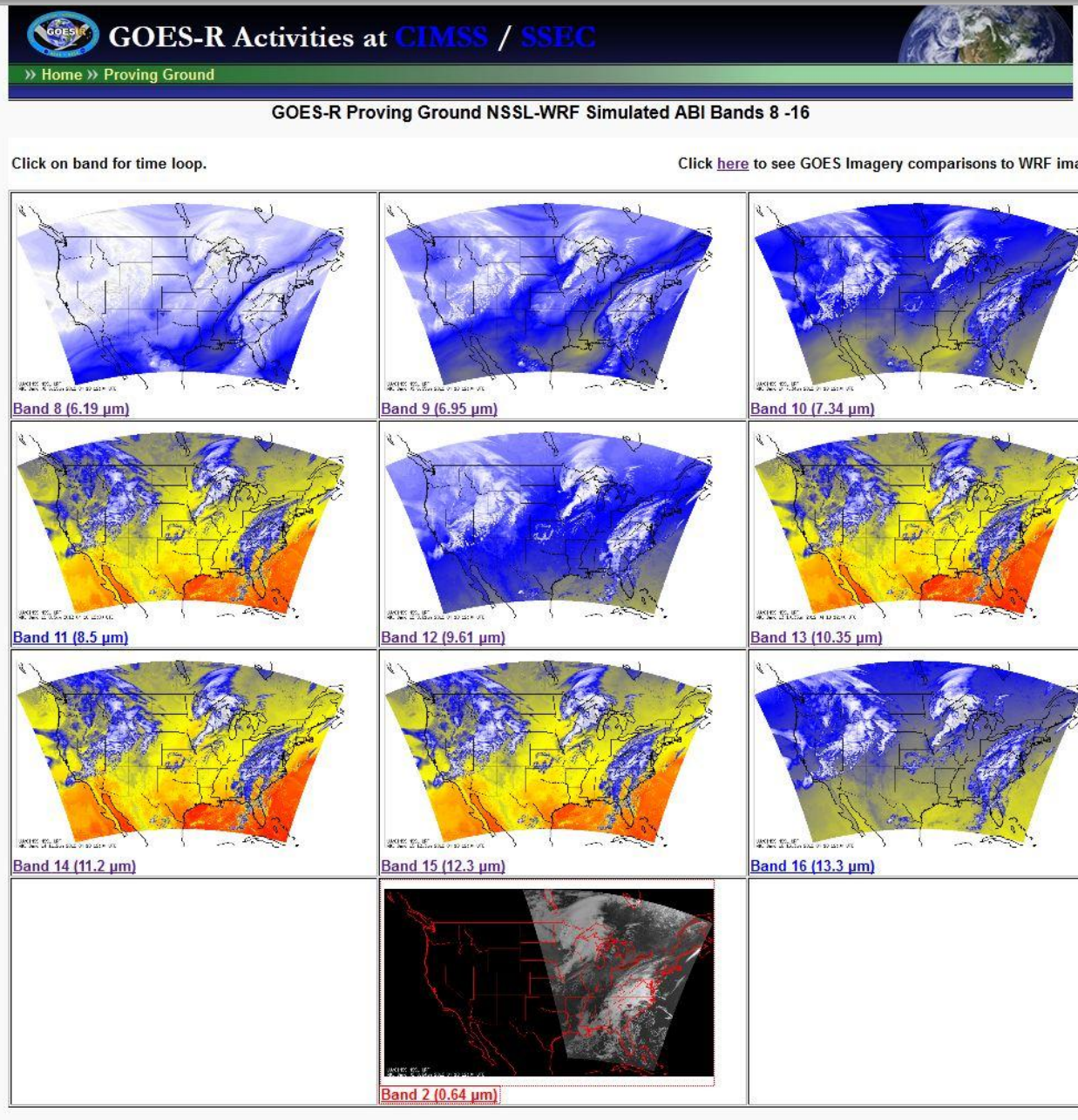


# Simulated ABI band – NSSL WRF



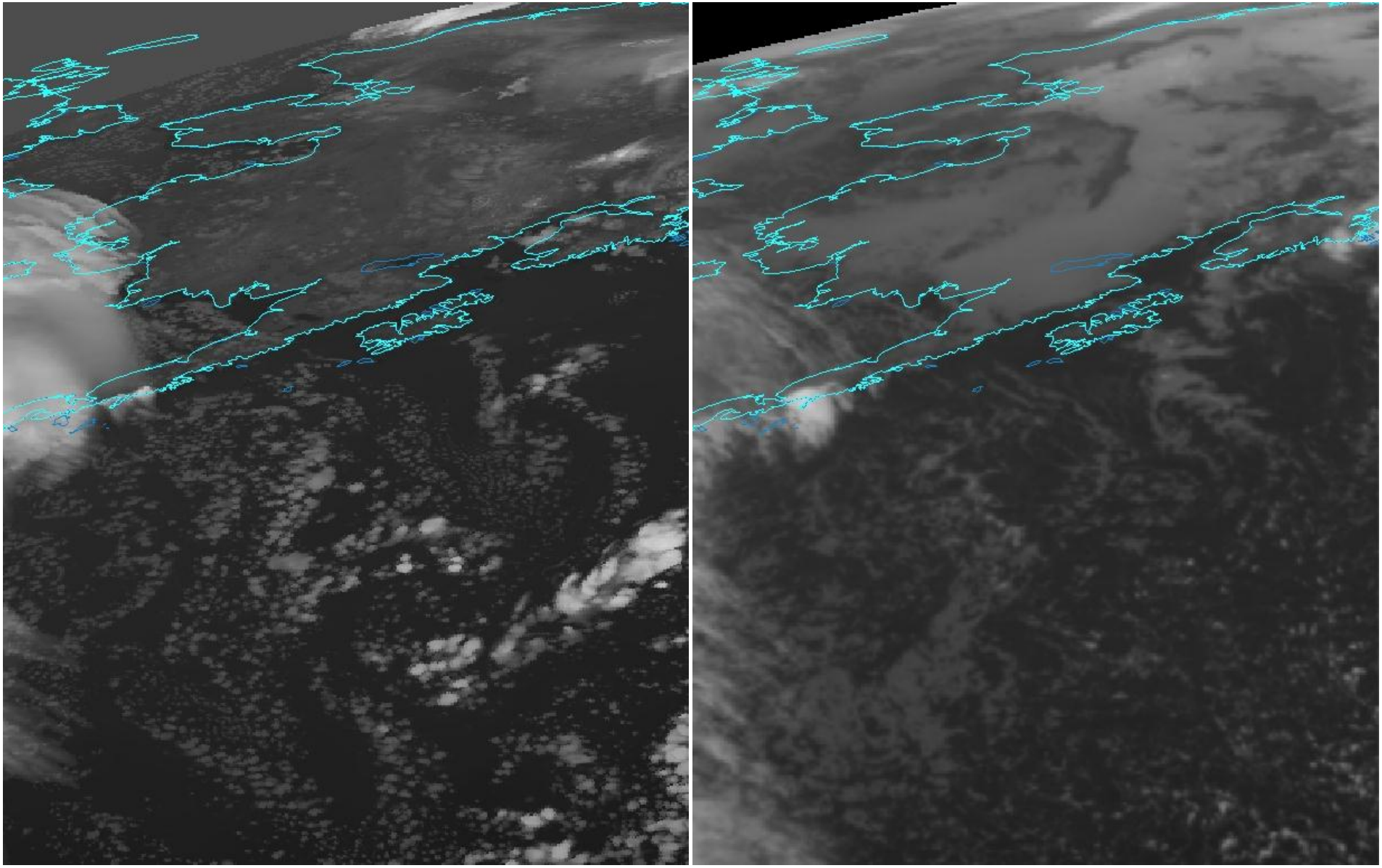

http://cimss.ssec.wisc.edu/goes_r/proving-ground/nssl_abi/nssl_wrf_goes.html

# Simulated ABI band – NSSL WRF



Simulated ABI – IR window

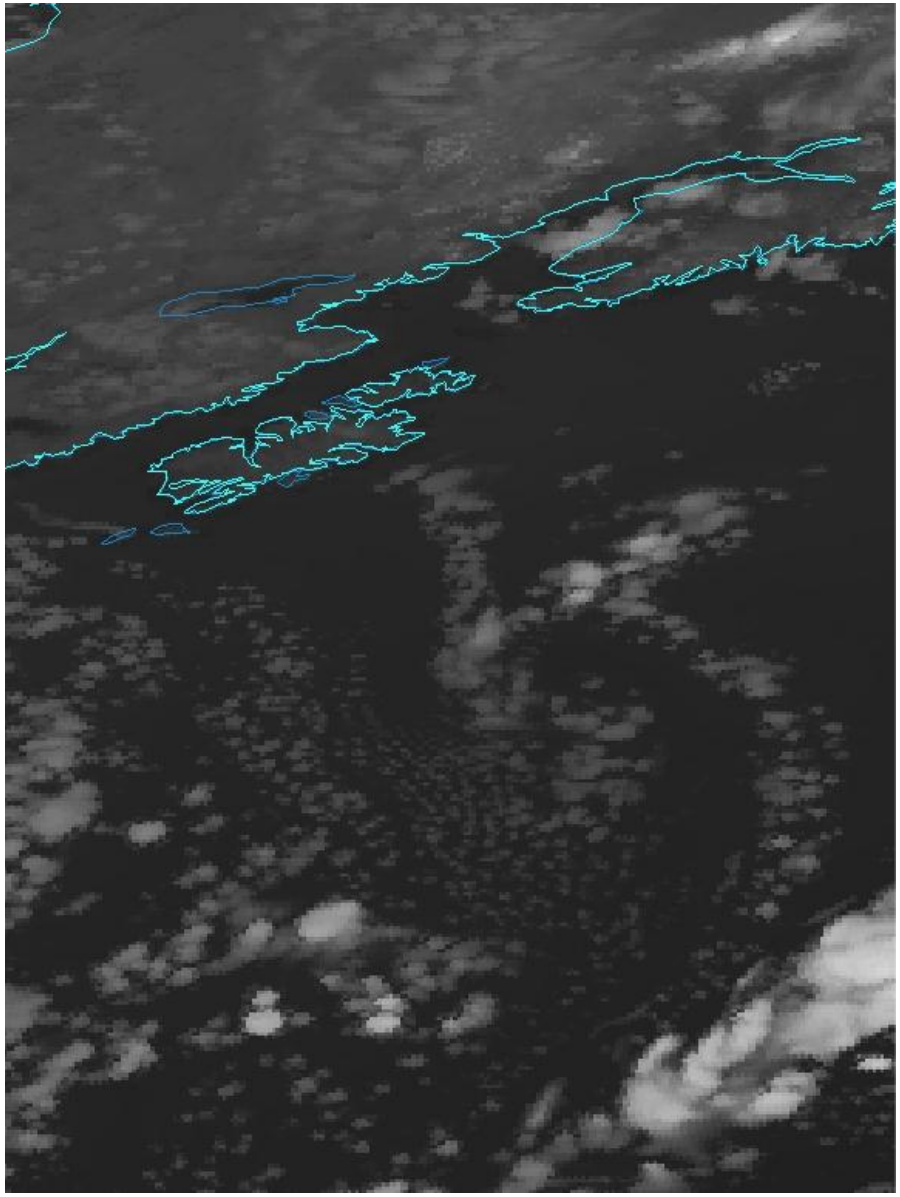
GOES Imager – IR window



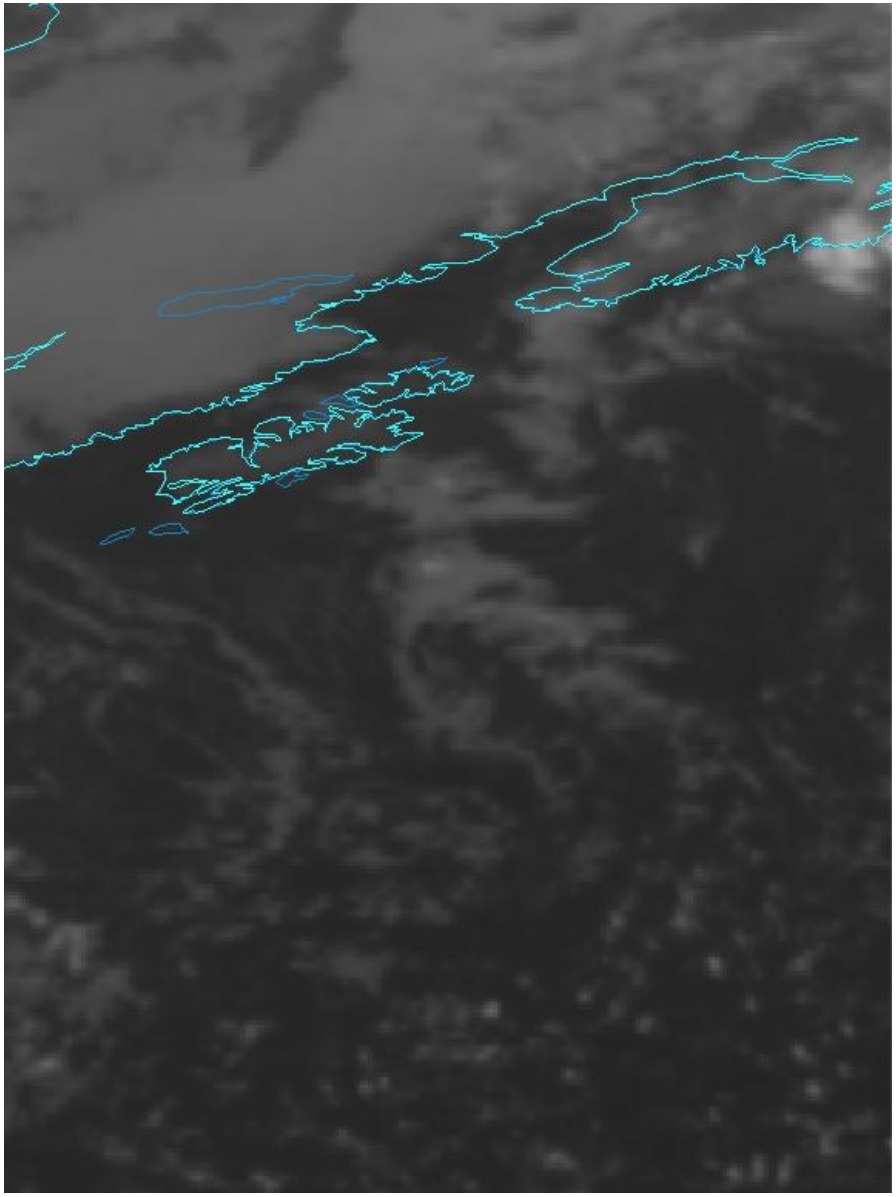
Both images shown in ABI projection using McIDAS-V. September 29, 2011 at 06 UTC

WRF runs at the Arctic Region Supercomputing Center

Simulated ABI – IR window



GOES Imager – IR window

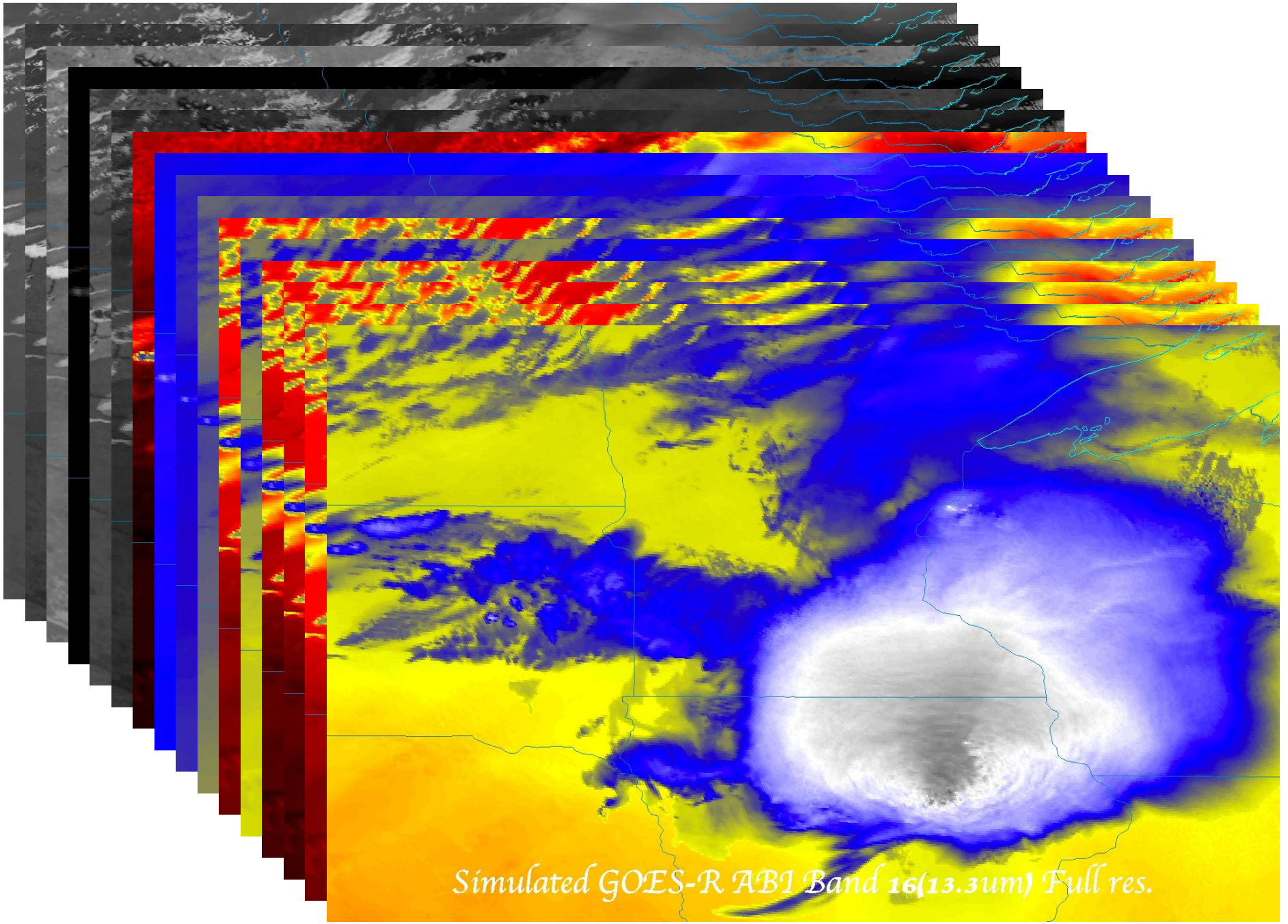


Both images shown in ABI projection using McIDAS-V. September 29, 2011 at 06 UTC

WRF runs at the Arctic Region Supercomputing Center

# Summary

- Imagery is the key product and hence needs a sufficient validation tool set.
- This tool set should at least include:
  - Thumbnail images
  - Full size and/or zoomed images
  - Animations
  - Times series of radiances/brightness temperatures
  - Statistics of radiances/brightness temperatures
  - Temporal difference images
  - Spectral band differences
  - Combine images
  - Product generation!
  - Forward model “Calc” vs “Obs” information
  - Etc.
- Need a flexible system, which allows zooming, roaming, specialized enhancements, etc.
  - Hope for the best, plan for the worst.
- Can’t wait for routine GOES-R routine imagery data!


Simulated GOES-R ABI Band 16(13.3um) Full res.

# Cloud and Moisture Imagery

## May 1, 2012

*Presented By:* Tim Schmit [1]
[1] NOAA/NESDIS/STAR

Thanks to the whole imagery team and all who gave inputs!